(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 031 987**
A1

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 80300052.0

(51) Int. Cl.³: G 05 F 1/56

(22) Date of filing: 04.01.80

(43) Date of publication of application:
15.07.81 Bulletin 81 28

(84) Designated Contracting States:
DE FR GB

(71) Applicant: FUJITSU FANUC LIMITED
5-1, Asahigaoka, 3-chome
Hino-shi, Tokyo 191(JP)

(72) Inventor: Imazeki, Ryoji
987-44, Naganuma-cho
Hachioji-shi Tokyo(JP)

(72) Inventor: Hattori, Masayuki
1271-41, Narahara-cho
Hachioji-shi Tokyo(JP)

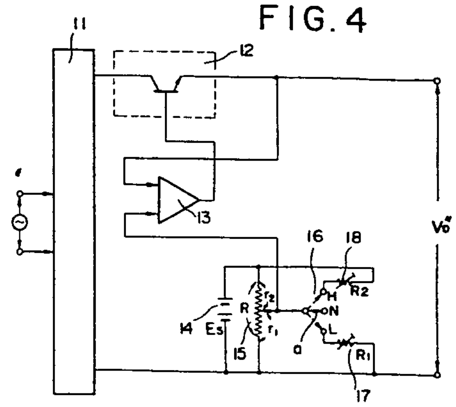
(72) Inventor: Nakamura, Shigeo
5540, Hino-shi
Tokyo(JP)

(74) Representative: Overbury, Richard Douglas et al,
HASELTINE LAKE & CO Hazlitt House 28 Southampton
Buildings Chancery Lane
London WC2A 1AT(GB)

(54) DC regulated power source apparatus.

(57) DC regulated power source apparatus for incorporation in electronic devices which, when equipment such as a sequence controller or numerical control unit for controlling a machine tool is subjected to maintenance or inspection, require that a power source voltage be shifted from a reference voltage by a fixed value. The DC regulated power source apparatus includes a first output voltage adjuster (4) capable of adjusting an output voltage (V_o'') to a desired value by means of a rheostat, and a second output voltage adjuster (18, 17) operated after the output voltage (V_o'') has been adjusted to the desired value by the first output voltage adjuster, the second output voltage adjuster being capable of shifting the adjusted output voltage (V_o'') by a prescribed amount to a value higher (18) or lower (17) than the desired value by simple manual or automatic switching (16, 19 to 23).

FIG. 4



EP 0 031 987 A1

0031987

DC REGULATED POWER SOURCE APPARATUS

This invention relates to a DC regulated power source apparatus, and more particularly to a DC regulated power source incorporated in an electronic device.

Electronic devices, such as communications equipment or sequence controllers and numerical control units for controlling machine tools, generally incorporate a DC regulated power source device which supplies their electronic components with a regulated DC voltage. These DC regulated power sources include a reference power source for generating a reference voltage, as well as an output voltage control element. The output voltage control element constantly compares the output voltage against the reference voltage and functions to hold the output voltage constant at all times by restoring the output voltage to the reference voltage when the former attempts to rise, or by raising the output voltage up to the reference voltage when the former attempts to drop.

The DC regulated power source devices referred to above usually produce the reference voltage through use of a Zener diode. However, since Zener voltages can differ slightly even for Zener diodes of the same type or grade, using the voltage obtained from such diodes as a reference voltage results in irregularities among the devices that receive the output voltage from the DC regulated apparatus. It is therefore conventional practice to employ a Zener diode of a higher Zener voltage than the reference voltage, and to divide this high Zener voltage down to an accurate reference voltage by means of a potentiometer.

When a machine tool is inspected or subjected to maintenance after installation in a factory, or when an inspection is carried out during the course of manufacture, there are cases where an operating margin test is conducted by shifting the operating voltage of a numerical control unit or sequence controller in the plus or minus direction by a prescribed value with respect to a rated voltage. When varying the voltage in this fashion, it is conventional practice to rotate, by small increments, the potentiometer which is used to divide the Zener voltage, thereby shifting the output voltage toward a prescribed value while closely observing an output voltmeter.

On the other hand, a hardware operating check has been facilitated greatly by automating the checking procedure or by providing machine tools, or the electronic devices which they incorporate, with a self-diagnosing function. It would be very convenient if the operating margin check could be interlaced with the other operating checks since this would permit a confirmation of the operating margin of the circuitry. However, since the output voltage has heretofore required to be adjusted by the manual operation of a potentiometer as described above, it has not been possible to insert into a series of automated testing steps an additional test step for confirming the operating margin of the circuitry.

According to the present invention there is provided a DC regulated power source apparatus for controlling an output voltage so as to limit the difference between the output voltage and a reference voltage to zero, which apparatus comprises a differential amplifier for detecting a difference in voltage between the reference voltage and output voltage, and a voltage control circuit responsive to an output signal from said differential amplifier to control the output voltage in such a direction as will limit said difference in voltage to zero, characterised by first output voltage varying means for setting the output voltage to a prescribed value, and second output voltage varying means for temporarily shifting to a preset value the output voltage which has been set to said prescribed value by said first output voltage varying means.

An embodiment of this invention can provide a DC regulated power source apparatus for incorporation in a variety of electronic equipment, the output of which apparatus can be finely adjusted to correct for discrepancies in the reference voltage of a reference power source, and which allows the output voltage to be shifted to a preset value by an operation command signal which does not require the intervention of an operator, or by a simple switching procedure performed by an operator.

An embodiment of the present invention can provide a DC regulated power source apparatus those output voltage can be finely adjusted in a continuous manner.

An embodiment of the present invention can provide a DC regulated power source apparatus whose output voltage, which has been adjusted to a prescribed value, can be shifted manually or automatically by a fixed amount.

An embodiment of the present invention can provide a DC regulated power source apparatus which, when the output voltage is shifted to a fixed voltage that is higher than a prescribed value, minimizes any error in the output voltage even if a reference voltage fluctuates.

The present invention will be more clearly understood by referring to the following detailed description when considered in conjunction with the accompanying drawings wherein:

0031987

Fig. 1 is a block diagram of a conventional DC regulated power source apparatus;

Figs. 2 and 3 are block diagrams of conventional DC regulated power source apparati whose output voltages are capable of being varied;

Fig. 4 is a circuit diagram illustrating a first embodiment of the present invention;

Fig. 5 is a circuit diagram illustrating a second embodiment of the present invention;

Fig. 6 is a simplified circuit diagram of the second embodiment shown in Fig. 5;

Fig. 7 is a simplified circuit diagram of a third embodiment of the present invention and;

Fig. 8 is a simplified circuit diagram of a fourth embodiment of the present invention.

Illustrated in Fig. 1 is a functional block diagram of a typical DC regulated power source apparatus which has long been known in the art. The apparatus includes a rectifying and smoothing circuit 1, a voltage control circuit 2, a differential amplifier 3, and a reference voltage power source 4 which supplies a reference voltage E_S. The differential amplifier 3 detects a difference in voltage between the reference voltage E_S and an output voltage V_O, and responds by controlling the voltage control circuit 2 in such a manner that the difference in voltage is limited to zero, thereby equalizing the output voltage V_O and reference voltage E_S at all times. A Zener diode is employed in the reference voltage power source 4. However, though Zener diodes may be of an identical type or grade, it is common for such diodes to provide Zener voltages which differ from one another to an extremely small degree. A prescribed voltage therefore cannot be obtained with the apparatus of Fig. 1 as long as it is not possible to acquire Zener diodes which can provide Zener voltages which are identical to the reference voltage E_S. It is for this reason that the systems shown in Figs. 2 and 3 are adopted in the prior art. In Fig. 2, for example, a rheostat 5 is employed to divide the reference voltage E_S, with the output voltage V_0' being adjusted to a desired value within the range of the reference voltage E_S. In Fig. 3, the output voltage V_0' is adjusted to a prescribed voltage through multiplying the reference voltage E_S by the ratio of the resistance value R of rheostat 5 to the divided resistance r.

The present invention, as will be described hereafter in connection with embodiments thereof, is based upon the DC regulated power source apparatus of the types shown in Figs. 1 through 3, in which a differential amplifier is used to compare an output voltage against a reference voltage, with a voltage control circuit being controlled in response to the output of the differential amplifier to hold the output voltage of the apparatus at a prescribed value.

Fig. 4 is a circuit diagram illustrating an embodiment of the present invention. The arrangement includes a rectifying and smoothing circuit 11, a voltage control circuit 12, a differential amplifier 13, a reference power source 14, a variable resistor 15,

0031987

a total resistance R, a three-point type switch 16, and rheostats 17, 18 having respective resistance values of R_1 and R_2.

The arrangement of Fig. 4 operates as follows. Movable contact a of switch 16 ordinarily is switched to neutral pole N. The output voltage V_O'' is decided by the voltage dividing ratio α ($\alpha = r_1/R$) determined by variable resistor 15, and the reference voltage E_S. In other words, $V_O'' = E_S\alpha$. When a difference between the output voltage V_O'' and a reference value is observed because of a variance in the Zener voltage of the Zener diode that constructs the reference voltage source 14, the output voltage V_O'' is set to the reference value as in the prior art by adjusting the rheostat 15 to change the dividing ratio α. The reference voltage E_S of the reference voltage source 14 is preset to a value which is higher than the operating voltage of the electronic circuitry, such as a value which is twice the operating voltage.

If the movable contact a of switch 16 is now switched from the neutral position N to a low voltage position L instead of changing the dividing ratio α by manipulating the rheostat 15, a variation in the dividing ratio α will obey the following relationship,

$$\alpha_L = \frac{r_1//R_1}{r_1//R_1 + r_2} < \alpha \text{ , where } r_1//R_1 = \frac{1}{1/r_1+1/R_1}$$

The above equation shows that the output voltage V_O'' drops to a fixed value by varying the dividing ratio α until it attains the value α_L. The fixed value to which the output voltage V_O'' drops can be varied by changing the value of R_1 through adjustment of the rheostat 17. Restoring the output voltage V_O" to the original value can be accomplished merely by switching the movable contact a back to the neutral position N.

If the movable contact a of switch 16 is next swithed from the neutral position N to a high voltage position H, the variation in the dividing ratio α now will obey the following relationship,

$$\alpha_H = \frac{r_1}{r_1+r_2//R_2} > \alpha \text{ , where } r_2//R_2 = \frac{1}{1/r_2+1/R_2}$$

The above equation shows that the output voltage V_O" rises to a fixed value by varying the dividing ratio until it attains the value α_H. The fixed value to which the output voltage V_O" rises can be varied by changing the value of R_2 through adjustment of the rheostat 18. As before, the output voltage V_O" can be restored to the original value merely by switching the movable contact a back to the neutral position N. The movable contact a can be switched over manually or automatically through the use of suitable drive means. One example in which the latter can be accomplished is by means of an electromagnetic switch whose contact is adapted to be switched over by an electromagnetic force.

Another embodiment will now be described in which output voltage is shifted to a fixed value higher or lower than a reference voltage, wherein the shift is accomplished automatically, by a command signal, or manually. Such an embodiment is shown in Fig. 5 in which portions that bear the same reference numerals as those in Fig. 4 are similar thereto and need not be described again.

Turning now to Fig. 5, a switching circuit is designated generally at 19, the circuit including stationary contacts h, n, l, a movable contact M, and a drive circuit 191 for actuating the movable contact M. Drive circuit 191 has a signal input terminal S. Movable contact M is switched to stationary contact n when signal input terminal S is at zero potential, to stationary contact h when input terminal S is at a positive potential (+5 volts), and to stationary contact l when input terminal S is at a negative potential (-5 volts). Rheostat 17 is connected to stationary contact l, and semi-fixed variable resistor 18 to stationary contact h. An OR gate 20 has its output side connected to the signal input terminal S of drive circuit 191, and has one input terminal X connected to a driving signal generator and its other input terminal connected to the variable contact of three-point switch 21. Sources of +5 and -5 volt signals are shown at 23 and 22, respectively.

When automatically shifting the output voltage by a fixed value to a level which is lower than a prescribed value, a -5 volt signal from the driving signal generator is applied to the input terminal X of OR gate 20, whereupon the signal is delivered to drive circuit 191 through the OR gate. Drive circuit 191 responds by switching the movable contact M to the stationary contact ℓ, whereby the output voltage is shifted downward by a fixed value as in the foregoing embodiment. When automatically shifting the output voltage by a fixed value to a level which is higher than a prescribed value, a +5 volt signal from the driving signal generator is applied to the input terminal X of OR gate 20, whereupon

0031987

the signal is delivered to drive circuit 191 through the OR gate. Drive circuit 191 now responds by switching the movable contact M to the stationary contact h, whereby the output voltage is shifted upward by a fixed value as in the foregoing embodiment. On the other hand, no signals are delivered to drive circuit 191 from the driving signal generator when the output voltage is to be maintained at the prescribed value. On such occasions the movable contact M is switched to the stationary contact n. If it is now desired to shift the output voltage upward or downward by a fixed value through a manual instead of the automatic method, the three-point switch 21 need only be manipulated by hand to apply the +5 volt signal or -5 volt signal to drive circuit 191.

In each of the foregoing embodiments, the range over which the output voltage is shifted from the reference value, that is, upward or downward from the reference value by the fixed value, is decided by the value of the reference voltage E_S, the value of the resistors, r_1, r_2, and the value of resistor R_1 or R_2. Fig. 6 shows a simplification of the circuitry of the two foregoing embodiments in order to simplify the description of the invention. It should first be noted that $E_O = \frac{r_1}{r_1+r_2} E_S = V_O''$, and

$$r_O = r_1//r_2 = f\ (E_S,\ V_O,\ R),$$

where $r_1//r_2 = \frac{1}{1/r_1+1/r_2}$. The range $\Delta V_O''$ over which the output voltage is varied in the circuit of Fig. 6 is defined by the following:

$$1)\quad \Delta V''_{OL} = E_O \frac{r_O}{r_O+R_1},$$

where $\Delta V''_{OL}$ represents downward change when the output voltage is lowered by a fixed value from the prescribed value, and

$$2) \quad \Delta V''_{OH} = (E_S - E_O)\frac{r_O}{r_O+R_2},$$

where $\Delta V''_{OL}$ represents upward change when the output voltage is raised by a fixed value from the prescribed value.

From the above it can be understood that, in the two foregoing embodiments, the closer the reference voltage E_S is to E_O, the more $\Delta V''_{OH}$ is influenced by fluctuation in the reference voltage E_S, and hence, the more $\Delta V''_{OH}$ itself fluctuates. Accordingly, when switch 16 is changed over to alter the value of the resistance that loads the reference voltage source, the current flowing through the Zener diode undergoes a large change. If the Zener voltage experiences even a small variation, this is accompanied by a fluctuation in the output voltage, the value of which will therefore differ from the design voltage. Hence, an embodiment which will be described next is adapted to enhance the precision at which the output voltage is raised by a fixed value from the prescribed value.

In this third embodiment as illustrated by the circuit diagram of Fig. 7, E_e is a separate power source of a higher voltage than E_O, and is suitably regulated by a Zener diode or the like. The range V'''_{OH} over which the output voltage is varied when terminals H and T are interconnected is given by the following equation,

$$\Delta V'''_{OH} = (E_e - E_O)\ \frac{r_O}{r_O+R_2}\ .$$

If E_e is suitably stabilized to a greater extent that

E_O, then the only fluctuation in $\Delta V''_{OH}{}'$ will be due to r_O (where r_O is a function of E_S, $V''_O{}'$, and R.) This fluctuation due to r_O can be substantially suppressed by adopting the circuit shown in Fig. 8, wherein the equivalent circuit shows a resistor r_O' inserted in series with resistor r_O, where $r_O' \gg r_O$. Adopting this circuit affords a further improvement in precision. This arrangement also enhances the precision at which the output voltage is lowered when terminals T and L are interconnected.

As evident from the foregoing description, the present invention includes first output voltage varying means for setting an output voltage to a prescribed value, thereby allowing a variance in reference voltage to be corrected. The invention further includes second output voltage varying means for temporarily shifting the prescribed output voltage, set by the first varying means, to a preset value, thereby allowing the output voltage to be shifted through a simple operation whenever maintenance and inspection are performed. This eliminates the troublesome adjustment procedure encountered in the prior art, wherein adjustment must be performed while a voltmeter is observed. Moreover, actuating the output voltage varying means by an externally applied signal allows a test step for confirming circuit operating margin to be inserted into a series of automated test steps. Further, when shifting the output voltage upward from a reference voltage by a constant value, two reference voltage sources may be used to provide a voltage difference which is divided down to a voltage that may then be employed as the reference voltage which is applied to a differential amplifier. The shifted voltage will therefore attain a value in conformance with the planned value.

CLAIMS

1. A DC regulated power source apparatus for controlling an output voltage so as to limit the difference between the output voltage and a reference voltage to zero, which apparatus comprises a differential amplifier for detecting a difference in voltage between the reference voltage and output voltage, and a voltage control circuit responsive to an output signal from said differential amplifier to control the output voltage in such a direction as will limit said difference in voltage to zero, characterised by first output voltage varying means for setting the output voltage to a prescribed value, and second output voltage varying means for temporarily shifting to a preset value the output voltage which has been set to said prescribed value by said first output voltage varying means.

2. A DC regulated power source apparatus according to claim 1, in which said first output voltage varying means is capable of continuously varying the output voltage by a rheostat.

3. A DC regulated power source apparatus according to claim 1 or 2, in which said second output voltage varying means temporarily shifts the output voltage which has been set by said first output voltage varying means, to a higher or lower voltage in a discontinuous manner.

4. A DC regulated power source apparatus according to claim 3, wherein the value by which the output voltage

is temporarily shifted can be finely adjusted by a rheostat.

5, A DC regulated power source apparatus according to any preceding claim, in which said second output voltage varying means is brought into operation manually.

6. A DC regulated power source apparatus according to any one of claims 1 to 4, in which said second output voltage varying means is brought into operation automatically by an externally applied control signal.

7. A DC regulated power source apparatus according to claim 5 or 6, in which said second output voltage varying means can be brought into operation either manually or automatically.

8. A DC regulated power source apparatus according to any preceding claim, in which, when shifting the output voltage to a higher voltage by said second output voltage varying means, two reference voltages are used to provide a voltage difference that is divided down to a voltage utilized as a reference voltage which is applied to said differential amplifier.

FIG. 1

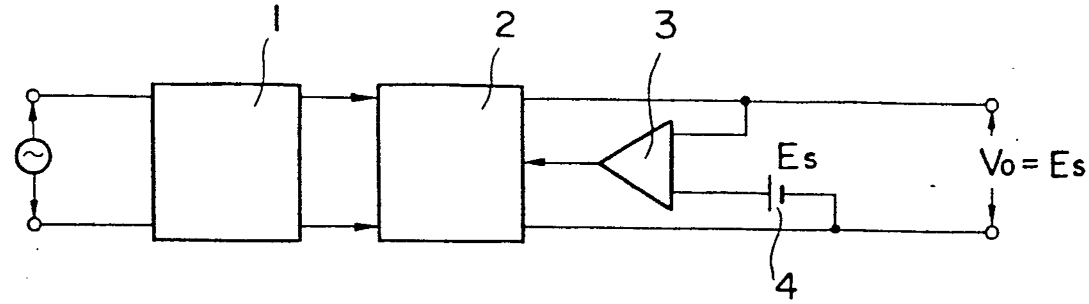


FIG. 2

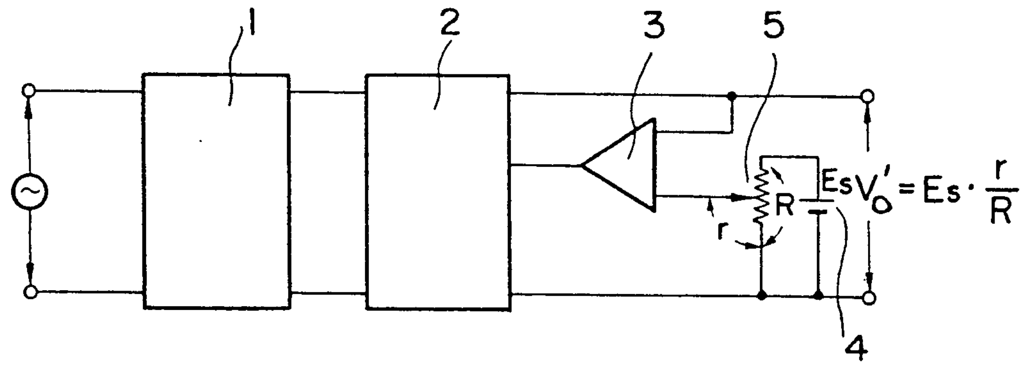


FIG. 3

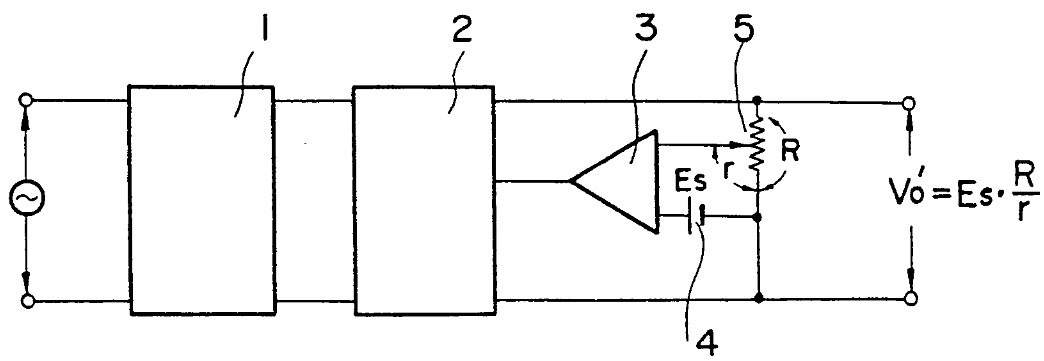


FIG. 4

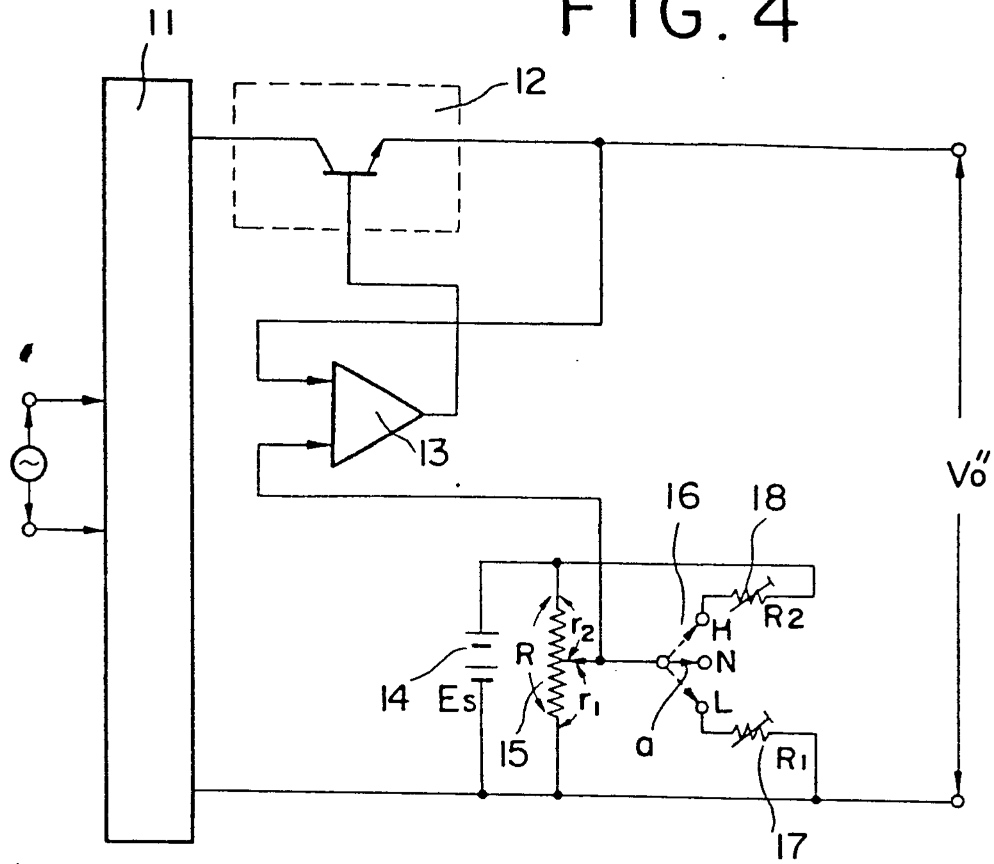
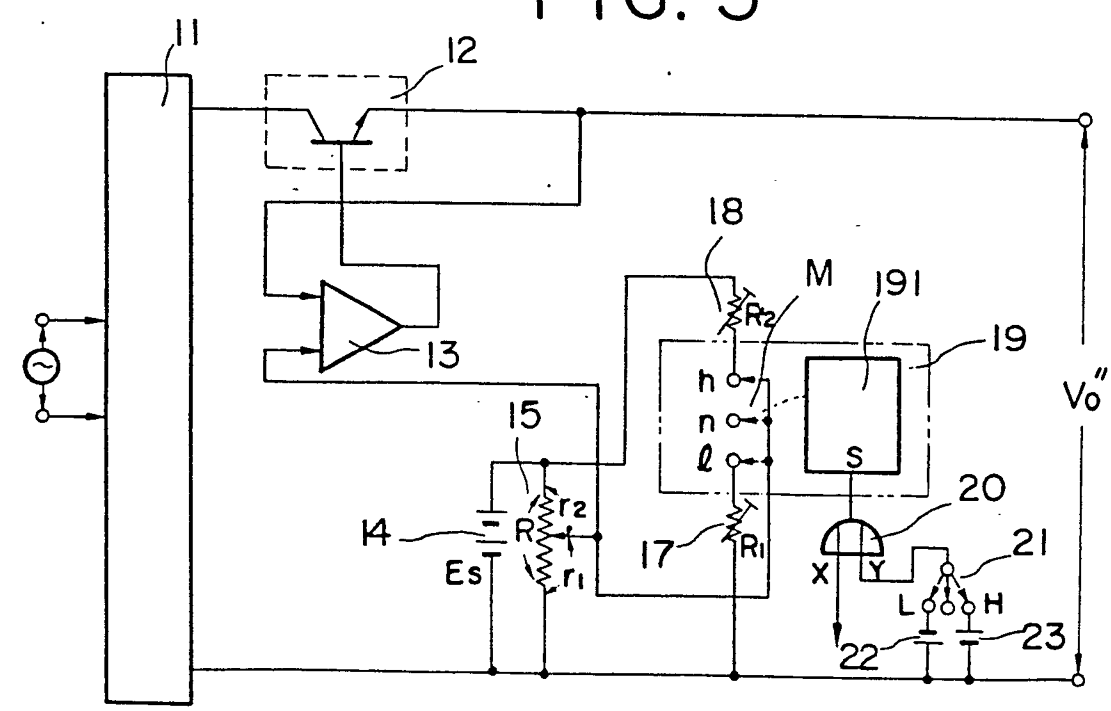

11
12
13
16
18
R2
H
N
L
a
R
r2
r1
14
Es
15
R1
17
Vo''

FIG. 5


11
12
13
18
M
191
19
R2
h
n
ℓ
S
15
r2
R
r1
14
Es
17
R1
20
X
Y
21
L
H
22
23
Vo''

3/3

FIG. 6

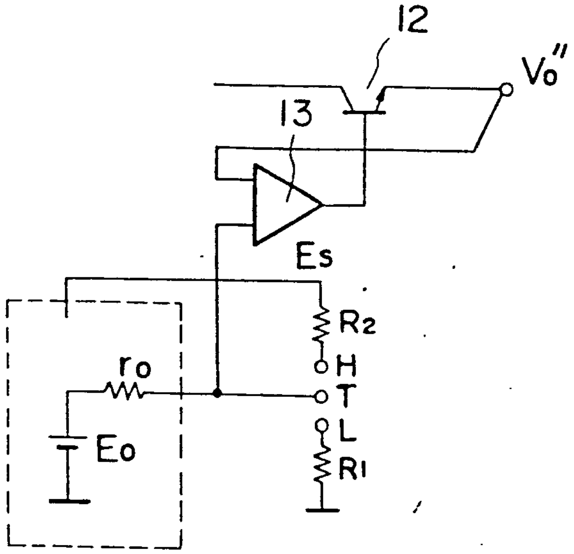


FIG. 7

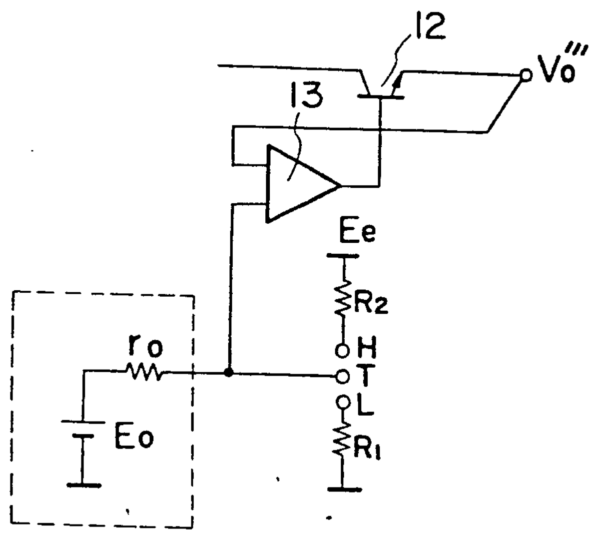
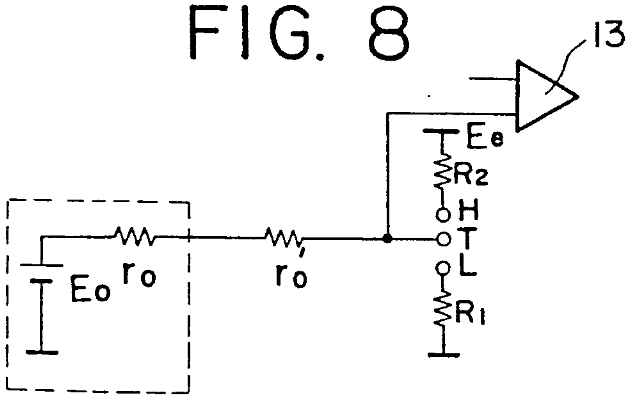


FIG. 8



European Patent Office

EUROPEAN SEARCH REPORT

0031987

Application number

EP 80 30 0052

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
	ELECTRONIQUE & MICROELECTRONIQUE INDUSTRIELLES, no. 162, 15th October 1972, pages 57-60 Paris, FR. C. BOISARD: "Un CI régulateur de vitesse" * Page 59, paragraphe: "Régulation de vitesse et commutation électrique de vitesse nominale"; figures 4,5 * --	1-3,5	G 05 F 1/56
	ELEKTOR, vol. 2, no. 7/8, July/August 1976, pages 739-740 Canterbury, G.B. G. EBNER: "0-30 V/1 A, stabilised" * Whole article * --	1-3,5, 8	TECHNICAL FIELDS SEARCHED (Int.Cl. ³) G 05 F 1/46 1/48 1/50 1/56 1/58
	ELECTRONICS, vol. 50, no. 15, 21st July 1977, page 125 New York, U.S.A. C. VISWANATH: "D-a converter controls programmable power source" * Whole article * --	6	
A	ELECTRONIC DESIGN, vol. 25, no. 7, 29th March 1977, page 104 Rochelle Park, U.S.A. G. BUURMA: "Simple CMOS keyboard encoder circuit" * Whole article * --	1	CATEGORY OF CITED DOCUMENTS X: particularly relevant A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: conflicting application D: document cited in the application L: citation for other reasons
A	US - A - 3 577 064 (FORBRO DESIGN) * Column 2, line 35 - column 5, line 67; figure 1 * -- ./.	1	&: member of the same patent family, corresponding document
X	The present search report has been drawn up for all claims		

Place of search	Date of completion of the search	Examiner
The Hague	20-08-1980	ZAEGEL

European Patent Office

EUROPEAN SEARCH REPORT

Application number
EP 80 30 0052

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
A	US - A - 3 566 252 (FORBRO DESIGN) * Column 2, line 13 - column 4, line 54; figure 1 * ----	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl. 3)